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ABSTRACT

Technology is viewed as a significant independent variable of the organization, affecting the organizational task structure. Viewing the classroom as the unit of observation, a technological change is introduced in the form of electronic computers to teach mathematics. Organizational task structure is defined in terms of teacher-pupil interaction as it relates to the "work" of the organization. An attempt is made to measure changes in task structure corresponding to the change in technology. (Author)

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THE EFFECT OF TECHNOLOGY ON SCHOOL ORGANIZATIONAL TASK STRUCTURE

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A TECHNOLOGICAL VIEW OF THE SCHOOL ORGANIZATION

In an age of increased emphasis on the role of instructional technology in the teaching-learning process, the effect of new technology on the school organization is of concern to educational administrators. Education is poised on the brink of a revolution in the use of instructional technology in the teaching-learning process. The state-of-the-art is so far advanced compared to application that diffusion of technology into education is inevitable. In light of this state of impending revolution in the instructional process posed by technology, there is an imminent need to assess the impact that a change of this magnitude will have on the structure of the school. It is crucial to be aware of the interrelationships between instructional technology and, say, the organizational goal structure. This study was an investigation of the effect of a specific form of computer technology on the task structure of the classroom organization.

Technology as a Major Variable in the School Organization

There is a need for a theory of school organization. To be sure, educators have borrowed from theory in other disciplines, but a compilation of this haphazard collection is in order. Carver and Sergiovanni pointed out that theories of educational administration have not sufficiently considered

the organizational context of the school.[1] At this time, an integrative piece of work on school organizational theory is nonexistent. Bidwell has reviewed the literature in The School as a Formal Organization,[2] but, at most, it is a compilation from one viewpoint--the sociological perspective--with limited theoretical discussion. One must go beyond this and examine organizational models in other disciplines, compare these paradigms to the school organization and refine those that seem to fit. Sometimes, the "goodness of fit" will have to be verified by empirical evidence.

A goal of this study is to initiate such an undertaking by examining a particular theory and subjecting it to the rigorous test of the real world situation. The theory to be examined is that which assigns technology as a major variable in the analysis of organizations. In fact, the technology of an organization is seen as affecting the entire structure and goals of the organization.

Let the technology of the organization be defined as a collection of techniques or technical factors which enable the "work of the organization to be conducted. This view recognizes that the organization uses many techniques to

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[1] Fred D. Carver and Thomas J. Sergiovanni, eds., Organizations and Human Behavior: Focus on Schools (New York: McGraw-Hill, 1969). pp. 1-3.

[2] Charles E. Bidwell, "The School as a Formal Organization," in Handbook of Organizations, ed. by James March (Chicago: Rand McNally, 1965), pp. 972-1022.

achieve its purposes, the sum of which constitutes its technology. Techniques, then, are:

> The actions that an individual performs upon an object, with or without the aid of tools or mechanical devices, in order to make some change in that object. The object or 'raw material,' may be living being, human or otherwise, a symbol, or an inanimate object.[3]

Stated another way, a technology is:

> A set of programmes to be put into effect when appropriate stimuli appear, and the strategies followed when new or unique stimuli appear, all for the purpose of changing raw materials (human, symbolic, or inanimate) into desired goods or services.[4]

The "raw material" of the classroom organization is defined as the affective[5] and cognitive[6] behaviors of the students in the classroom. The "processing" of this raw material, presumably in a positive manner, constitutes the "work" of the organization. A technology, that is, a set of techniques, exists for doing this work. Thus, Knezevich and

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[3] Charles Perrow, "A Framework for the Comparative Analysis of Organizations," American Sociological Review, XXXII (April, 1967), 194-208.

[4] Charles Perrow, "The Effect of Technological Change on the Structure of Business Firms," in Industrial Relations: Contemporary Issues, ed. by B. C. Roberts (New York: Macmillan, 1968), p. 208.

[5] David R. Krathwohl, Benjamin S. Bloom and Bertram B. Masas, Taxonomy of Educational Objectives: The Classification of Educational Goals: Handbook II, The Affective Domain (New York: David McKay, 1964).

[6] Benjamin S. Bloom, ed., Taxonomy of Educational Objectives: The Classification of Educational Goals: Handbook I, Cognitive Domain (New York: David McKay, 1956).

Eye operationalized technology at the classroom level by defining instructional technology to be "an effort with or without machines, available or utilized, to manipulate the environment of individuals in the hope of generating a change in behavior or other learning outcome."[7]

Other variables of the classroom organization are its structure and goals. Perrow defined structure as "the arrangements among people for getting the work done."[8] More precisely, he stated:

> In the course of changing this material in an organizational setting, the individual must interact with others. The form that this interaction takes we will call the structure of the organization. It involves the arrangements or relationships that permit the coordination and control of work.[9]

This description is consistent with that of Hunt who defined structure as "the varied patterns of interaction, intended or otherwise, that characterize an organization."[10]

The distinction between technology and structure may have gray areas. Perrow pointed out this fact when he stated:

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[7]Knezevich and Eye, ed., <u>Instructional Technology and the School Administrator</u>, p. 16.

[8]Perrow, "A Framework for the Comparative Analysis of Organizations," p. 195.

[9]<u>Ibid</u>.

[10]Raymond G. Hunt, "Technology and Organization," <u>Academy of Management Journal</u>, XIII (September, 1970), pp.237.

> . . . It is the difference between an individual acting directly upon a material that is to be changed and an individual interacting with other individuals in the course of trying to change the material. In some cases the material to be changed and the 'other individuals' he interacts with are the same objects, but the relationships are different in each case.[11]

Perrow's theory, then, stated that the technology of the organization acts as an independent variable and the structure and goals must adjust to the technology or the organization will be subject to strong strains. This study examined the effect of technology on the classroom structure in terms of the pupil-teacher interaction. The rationale was to use technology to "unfreeze" the current structure of the classroom.

The problem, may then be stated in specific terms in the form of the following null hypothesis:

> When the technology of the classroom organization is altered by introducing electronic computers and calculators into certain mathematics classes to be used by the teachers at their discretion, there will be no resulting change in the organizational task structure.

Technology and Planned Organizational Change

It is inconceivable to discuss the introduction of new technology in the absence of the general concept of organizational change--in particular, planned organizational change. Following Gross, et al., organization change shall

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[11]Perrow, "A Comparative Analysis of Organizations," p. 195.

refer to changing organizational behavior of members.[12] Organizational innovation refers to a proposed set of ideas about how the organizational behavior of members should be changed in order to resolve problems of the organization or imporve its performance.[13] Finally, planned organizational change is defined as "the total process that may occur in efforts to deliberately alter organizational behavior through the introduction of innovations."[14]

The evidence cited above implies that technology can affect organizational structure, behavior, and productivity. It seems clear that there is a systemic interdependence among the subsystems of an organization: Changes cannot be affected in the technical system without reverberations in the social system. Katz and Kahn's description of open system theory in organizations[15] enables them to deal with the relatedness of subunits or parts of a system vis-a-vis the organization's environment. The authors saw a relationship between the necessary effect of the interrelatedness of subsystems and the degree of organizational change which can be effected. Systemic change involves changed inputs from the environment which create internal strain and imbalance among system subunits.

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[12] Neal Gross, Joseph B. Giacquinta, and Marilyn Bernstein, An Attempt to Implement a Major Educational Innovation: A Sociological Inquiry (Cambridge, Mass.: Harvard University, Center for Research and Development on Educational Differences, 1968), pp. 14-15.

[13] Ibid.

[14] Ibid.

[15] D. Katz and R. L. Kahn, The Social Psychology of Organizations (New York: John Wiley & Sons, 1966, pp. 19-29.

It is this internal strain which is the potent cause of the adaptation of subsystems indirectly connected with the change input. Guest,[16] Mann and Hoffman,[17] Marrow, et al.,[18] and Woodward,[19] among others, support the notion of interrelatedness of subsystems and the importance of considering the derivative effect on the social system of significant changes in technology.

Thus, it seems established that when technological change is considerable, some effects on the social system must be recognized and planned. However, the question of coordination of change is critical and is still unanswered. Is technological change the best way of achieving organizational change, or would it be more effective purposefully to change the social system, following that by planned changes in the organizational technology, or to change both simultaneously? Several studies have considered social change not only resulting from the new technology itself, but resulting from a planned social change input made possible, at least in part, by the disruption created by the

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[16] Robert H. Guest, Organizational Change: The Effect of Successful Leadership (Homewood, Ill.: The Dorsey Press, 1962), p. 55.

[17] Floyd C. Mann and L. Richard Hoffman, Automation and the Worker (New York: Henry Holt and Co., 1960), p. 193.

[18] Alfred J. Marrow, David G. Bowers, and Stanley E. Seashore, Management by Participation (New York: Harper & Row, 1967), p. 229.

[19] Joan Woodward, Industrial Organization: Theory and Practice, p. 239.

technological change.[20] The dynamic created is that of a force toward total system restructuring to find a new equilibrium. It seems possible that social system changes can occur without technological change, but organizations may not be able in themselves to provide the force necessary. Williams and Williams, for instance, found that such changes were not possible without a catalyst-like expenditure on technological change which creates stresses forcing departments and units to compromise on objectives and abandon traditional routines and activities.[21] Trist, et al., maintained that even limited technological changes can create enough disruption if their potentiality for inducing social change is recognized.[22] This kind of disruption has been labeled "unfreezing" by Lewin.[23] Taylor, upon reviewing the research where introduced technology preceded and succeeded social system change, concluded:

> The direct effect of technology on social system changes seems to involve the dynamic of constraints applied on employee behavior. The dynamic of ungreezing, on the other hand, seems

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[20]Alfred J. Marrow, David G. Bowers, and Stanley E. Seashore, Management by Participation; also, A. K. Rice, The Enterprise and Its Environment; E. L. Trist, et al., Organizational Choice; and Lawrence K. Williams and C. Brian Williams, "The Impact of Numerically Controlled Equipment on Factory Organization," California Management Review, VII (Winter, 1964), 25-34.

[21]Lawrence K. Williams and C. Brian Williams, "The Impact of Numerically Controlled Equipment on Factory Organization."

[22]E. L. Trist, et al., Organizational Choice, p. 284.

[23]Kurt Lewin, Field Theory in Social Science (New York: Harper & Row, 1951).

> to be a freedom provided by the new technology to seek new ways of behaving . . . It seems clear that the combination of direct and indirect effects of technology on the social system provides the basis for concluding that technological change would best precede social change in that it probably requires less time and elicits less resistance. This is true because technology not only disrupts or unfreezes, but imposes strict, nonhuman controls on minimum behavior.[24]

In addition to timing the use of technology in the change process, there is also the consideration of placement in the organizational hierarchy. Argyris suggested that effective organizational change comes about by improving interpersonal competence directly at the top of the organization, while improving it at the bottom more indirectly through changes in technology and control systems.[25] This seems similar to the Tavistock notion that the sociotechnical system operates primarily at the lower part of the organizational hierarchy. The Tavistock group was primarily concerned with the production system as sociotechnical systems. It is implicitly clear in these studies, however, that effective introduction of technological change for ultimate organizational change involved the upper ranks, either in a commitment to plan adequately for social system effects,[26] or in a commitment to the technological change

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[24] James C. Taylor, Technology and Planned Organizational Change, pp. 18-19.

[25] Chris Argyris, Interpersonal Competence and Organizational Effectiveness (Homewood, Ill.: Irwin-Dorsey, 1962), p. 82; also, David J. Hickson, et al., "Operations Technology and Organization Structure."

[26] E. L. Trist, et al., Organizational Choice.

itself as a method of improving social relationships.[27] Thus, in addition to concluding that technological change would best precede social change, it also appears that technology is best utilized near the bottom of the organizational hierarchy.

Even though the theoretical models of open systems and socio-technical systems underlying organizational change strategies are relatively new, there has been ample atheoretical writing about how management should institute technological change. These writings indicate that it would be naive to assume that technology alone can precipitate planned organizational change. As Bennis pointed out, anticipated change will be resisted to the degree that the client-system possesses little or incorrect knowledge about the change, has relatively little trust in the source of change, or has relatively low influence in controlling the nature and direction of change.[28] In this respect, there are certain necessary prior conditions for technological change. The company must first have good labor relations, high employee satisfaction, and mutual trust and goodwill.[29] This suggests that if these conditions are not met, then management must undertake to improve them before considering a technological change. The alternatives open to the

[27] R. H. Guest, Organizational Change: The Effect of Successful Leadership (Homewood, Ill.: The Dorsey Press, 1962); also, A. J. Marrow, et al., Management by Participation.

[28] Warren G. Bennis, Changing Organizations (New York: McGraw-Hill, 1966), p. 175.

[29] F. C. Mann and L. R. Hoffman, Automation and the Worker, pp. 199-200; also, W. H. Scott, ed., Office Automation (Paris: Organization for Economic Co-operation and Development, 1965), p. 93.

organization are selling out, wholesale dismissal of disgruntled employees, or moving to a new location and starting afresh--hardly viable alternatives for a school organization.

In the case of service organizations such as schools, there may also be resistance to change on the part of the public due to what Carlson called "domestication of public schools."[30] The resistance may be the result of an economy-minded school board or feedback loops (from the public through the board) designed to keep the system in a steady state. In these cases, and the above mentioned intra-organizational barriers to change, Miles advocated the use of temporary systems to bypass or avoid these barriers.[31] Temporary systems are characterized by specific time limits set on activities; a sharply focused range of content; specific boundary maintenance operations, e.g., classes of personnel who may enter the system; and, physical and social isolation of participants, thus serving as a protective function and a reducer of resistance to change based on the group norms of permanent systems.[32] As Miles stated:

> Temporary structures can help innovators avoid the temptation to be palliative about the

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[30] Richard O. Carlson, et al., Change Processes in the Public Schools (Eugene, Oregon: Center for the Advanced Study of Educational Administration, 1965), pp. 4-7.

[31] Mathew B. Miles, "On Temporary Systems," in Innovation in Education, ed. by Mathew B. Miles (New York: Teachers College Press, 1967), p. 443-44.

[32] Ibid., pp. 452-62.

> inadequacies of fundamentally bad permanent structures; they can enable vigorous, thoroughgoing development of innovations which might otherwise never make it through the protective fog of the status quo.[33]

Many educational changes take place under protective umbrella of temporary systems, e.g., federal and state supported research projects. This study was undertaken in a similar milieu.

Significance of the Study

It would appear from the literature that technology can play a major role in planned organizational change. In particular, technology can provide an "unfreezing" effect on the structure of the organization. This "unfreezing", combined with effective pre-technology and post-technology planning can lead to far reaching, permanent organizational change.

The study described herein focused on school organizational change in the form of new structures for teaching and learning mathematics at the elementary and secondary levels. Using Cunningham's terminology,[34] an "external" change agent, represented by a research team, set up a temporary system for overcoming any barriers to the change. Following the guidelines described above, administrators and teachers who appeared favorable to the change were allowed to enter the system and the technological change

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[33] Ibid., p. 485.

[34] Luvern L. Cunningham, "Viewing Change in School Organizations," Administrator's Notebook, XI (September, 1962).

occurred within a specified subsystem, called the "experimental group," which was near the bottom of the school organizational hierarchy, specifically, the classroom. By working with cooperative teachers and administrators the research team attempted to cultivate "internal" change agents who would eventually develop more permanent subsystems within their various school districts.

Specifically related to this study is the significance of educational technology on the traditional classroom mechanistic management system. As Amidon and Flanders pointed out: "In the average classroom someone is talking two-thirds of the time. Two-thirds of the time the person who is talking is the teacher. Two-thirds of the time the teacher is talking he is using direct influence."[35] There is tremendous pressure at all levels of education to adapt modes of instruction to suit the learner. Silber predicts that through technology the learner can become the initiator of the learning need and his own chief planner/manager in selecting or designing the learning experience to meet his needs.[36] Comparing this "environment-based" learning to "teacher-based" learning, Taylor stated:

> What is the essential difference between these attempts and conventional teaching? It lies in the <u>relationship of the learner to the source</u>

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[35] Edmund J. Amidon and Ned A. Flanders, The Role of the Teacher in the Classroom (Minneapolis, Minn.: Paul S. Amidon and Associates, 1963).

[36] Kenneth H. Silber, "Technology and Freedom," Educational Technology, XII (January, 1972), 27-34

> of instruction. Put more starkly: 'I am taught' (passive); 'I learn" (active); when I learn I go to something; when I am taught it comes to me....[T]he notion of learning as opposed to 'being taught' must also include the concept of independence.[37] (Italics in original).

Referring to learner autonomy, Heathers made a similar distinction between "independent learning" and individualized learning."[38] Speaking for many champions of educational reform he stated: The most fundamental reason for teaching the student to learn independently is that, throughout his life, his capabilities of expressing individuality in his choices and actions will be measured by his competencies in self-directed use of his mind.[39] The above authors and others express faith in the potential of instructional technology to usher in a new era of education emphasizing learner independence. However, technological advances hailed as breakthroughs in the past have fallen short of the projections. Consider, for example, the technological changes brought about by the language laboratory with its complex electronic system. Heinich pointed out that many such labs were misused and sometime abandoned.[40] The significance of this study lies in examining the effect of instructional technology on classroom structure. If change toward more autonomous group structures is desired,

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[38] Glen Heathers, "Educational Philosophy and Educational Technology," in To Improve Learning, ed. by Sidney G. Tickton, II (New York: R. R. Bowker, 1971), p. 105.

[39] Ibid., p. 110.

[40] Robert Heinich, "Technology and Teacher Productivity," Audiovisual Instruction, XXVI (January, 1971), 79-82.

then either the introduced technology enhances this change, whereby proper management support can guarantee execution of the planned organizational changes, or the effects of technology are rejected by the existing staff, whereby management may have to seek out other alternatives to meet its objective. This may be reflected in extensive inservice programs or in hiring practices.

Limitations of the Study

This study is limited in its perspective to that set of districts, schools and classrooms involved in the project. This consisted of eight "volunteer" school districts in Southern California with attendances ranging from 2,958 students to 36,801 students, and, having an average of 17,107 students. There are inherent problems when dealing with many large school districts, one of which is the ability to maintain a "controlled" experiment. For instance, other technological changes which might take place besides the introduction of computers cannot be hindered for the sake of the experiment; but it is assumed that such changes are not out of the ordinary and are controlled through randomization, and affect the comparison group and the control group in essentially the same way.

The Study

In the Spring of 1970 the superintendents of the school districts of Orange County, California, were contacted about participating in an extensive computer project. The project would involve certain mathematics classes as trial

centers for an innovative approach to teaching and learning mathematics. The innovative approach consisted of the use of electronic computers and calculators as supplemental aids to study mathematics. Eight school-districts agreed to participate and submitted names of interested teachers.

The teachers that had volunteered to participate in the experiment were randomly assigned to either the "experimental" group (using computer) or the "control" group (not using computers) with the specification of maximizing the number of pairs of control versus experimental in each subject level. The students were enrolled for the classes with no prior knowledge that their teacher might be involved in the project. Thus, from the population of students in grades four through twelve of the participating Orange County school districts, and taking mathematics classes from volunteer teachers, a sample was randomly generated by choosing "classes" of students to participate in the experiment. This amounted to some 16,000 students and 150 teachers in forty-four schools.

To measure changes in organizational task structure of the classroom, an observation system was employed using videotape recordings of the class lessons. Thus, control and experimental classes were videotaped and the lessons analyzed to note differences in task-related interactions between the two groups. This taping took place toward the end of the school year, after the experimental classes had ample opportunity to integrate the computers into their course procedure. The magnitude of the endeavor (in time and

expense) to videotape all the participating classes led to the alternative procedure of observing a random sample of the class population. Since the subject matter taught, e.g., general math, algebra, geometry, trigonometry, was viewed as a major contributor to classroom interaction, a stratified sample by subject matter was made from all participating classes. This resulted in the subject-matter groupings, and respective pairs of teachers randomly chosen from each subject-matter group, displayed in Table 1. The assumption was made that the teacher would be the major determinant of the classroom interaction--as Flanders pointed out, "the behavior of the teacher, more than any other individual, sets the climate of the class."[41] For this reason, it was decided that a teacher could be represented in only one subject matter grouping in order not to bias the within-

TABLE 1

SUBJECT-MATTER GROUPING AND RESPECTIVE SAMPLE SIZE OF EXPERIMENTAL AND CONTROL TEACHERS CHOSEN FROM THE C.O.M.P. POPULATION

Subject-Matter Group	Usual Grade Level	Number of Experimental-Control Pairs Chosen
Math Analysis	12	1
Algebra II/Trigonometry	11	2
Geometry	10	2
Algebra I	9	3
Pre-Algebra/General Math	9	2
Math 7/Math 8	7,8	2
Elementary Math	4-6	1

[41] Edmund J. Amidon and Ned A. Flanders, The Role of the Teacher in the Classroom (Minneapolis, Minn.: Association for Productive Teaching, 1971), p. 73.

treatment variability due to teachers.

In summary, the sample consisted of thirteen experimental teachers and thirteen control teachers chosen from seven subject-matter categories according to the proportion of classes for each category in the COMP population.

Procedures for Data Collection

Each class in the sample was visited twice during the last six weeks of school and the "middle" twenty minutes of each lesson recorded on videotape. This resulted in fifty-two videotapes, three of which were unusable due to poor quality recordings. Circumstances related to the termination of the school term made it impossible to re-tape these classes. The remaining forty-nine taped lessons were coded using the Flanders Interaction Analysis Category (FIAC) system. These tapes were randomly assigned to three coders for analysis. Several tapes were coded by two or more coders and coefficients of inter-coder reliability derived. These coefficients were beyond the minimum acceptable level of .80.

By observing certain patterns within the interaction matrix Flanders has derived certain indices of pupil initiation (student autonomy), and indirect teaching behavior (democratic leadership). Maxey has also developed an index for teacher flexibility[42]-- a variable which he defines as

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[42]James H. Maxey, "Analysis of Observational Data" (paper presented at the Annual Meeting of the American Educational Research Association, New York, February, 1971), p. 3

choosing an appropriate teaching style for a given occasion.[43] These specific indices of democratic leadership or a more open classroom climate derived from the FIAC system 10 x 10 matrix are: Teacher Talk Ratio, Pupil Talk Ratio, Content Cross Ratio, Steady State Ratio, Pupil Steady State Ratio, I/D Ratio, Pupil Initiation Ratio, Revised I/D Ratio, Instantaneous Teacher Question Ratio, Instantaneous Teacher Response Ratio, Teacher Flexibility Ratio, and Extended Indirect Influence Ratio.

Statistical Techniques Employed

The statistical techniques included consideration of the design and choice of an appropriate statistical model for analysis of the data.

The Design

The design follows that of Campbell and Stanley: Design 6, the "Postest-Only Group Design." Its form is as follows:

$$\begin{array}{ccc} R & X & 0_1 \\ R & & 0_2 \end{array}$$

where R represents a random assignment of subjects to X, the treatment, and $0_1, 0_2$ are observations of subjects after treatment. Classes were "randomly assigned" to control and experimental treatments by randomly assigning their teachers to respective treatments.

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[43] *Ibid.*, p.2

Data Analysis

The data generated were analyzed within the construct of a two-way analysis of variance, mixed model, using the two factors:

A: Treatment (Experimental, Control);

B: Teacher Pair ($T_1, T_2, \ldots, T_{13}$);

with replication, that is the teachers were observed twice. The usual assumptions are made for analysis of variance, i.e., (1) the distribution of the dependent variable (task structure index) in the population from which the samples are drawn is normal; (2) the variances in the populations from which the samples are drawn are equal; and (3) the effects of the factors on the total variation are additive.

The following null hypothesis was tested for each of the background variables, namely, I/D Ratio (IDR), Revised I/D Ratio (REVID), Pupil Initiation Ratio (PIR), Teacher Talk Ratio (TTR), Pupil Talk Ratio (PTR), Instantaneous Teacher Response Ratio (TRR89), Instantaneous Teacher Question Ratio (TQR89), Content Cross Ratio (CCR), Steady State Ratio (SSR), Pupil Steady State Ratio (PSSR), Extended Indirect Influence Ratio (EIIR), and Teacher Flexibility Ratio (TFR):

A: Treatment effects, $\sigma_A^2=0$ (which is equivalent to $\mu_{1..} = \mu_{2..}$).

Since teachers were chosen at random within a particular subject-matter goup, the factors Teacher and Treatment are not completely crossed. However, because teachers were not chosen at random from the entire populations of experimental teachers and control teachers the model is not, strictly

speaking, the nested model either. A test was made of the efficacy of pairing teachers by subject matter group. If teachers are not paired, that is, teachers are assumed to be randomly chosen from the whole experimental or control groups, then one essentially has a nested model--Teachers nested within Treatment. This would mean that the Teacher Pair and Interaction sums of squares could be pooled. A suggested procedure which has some theoretical justification is to average, or pool, Interaction and Teacher Pair sums of squares if the ratio of the Interaction and Teacher Pair mean squares is less than twice the 50th percentile of the F-distribution.[44] In those cases for which the $\frac{MS_B}{MS_{AB}}$ ratios of the background variables meet this criterion, the SS_B and SS_{AB} are pooled into a single component called "Teacher." Since the nested model is the underlying assumption, B (Teacher) is nested within A (Treatment), written B(within A) or B(A), and the pooled sum of squares $SS_{B(A)}=SS_A+SS_{AB}$.

The hypothesis of no effect due to treatment was tested under the nested model for those background variables meeting the pooling criterion. This hypothesis is summarized in Table 2 for the crossed and nested models.

It should be noted that the F-ratios are only approximate due to missing data and also due to the fact the $\frac{MS_A}{MS_{AB}}$ does

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[44] A.E. Paull, "On a Preliminary Test for Pooling Mean Squares in the Analysis at Variance," *The Annals of Mathematical Statistics* XXI (1950), 539-56.

not follow an F-distribution when $\sigma_A^2 = 0$ is true.[45] In the first case, it is possible under the nested model to get an estimation of the error caused by the missing data.[46] In either case, if the F-ratio is clearly significant or clearly not significant, there is no problem. Otherwise the results are to be interpreted with caution.

TABLE 2

SUMMARY OF HYPOTHESIS UNDER CROSSED AND NESTED MODELS

	Hypothesis	F-ratio
A:	$\sigma_A^2=0$	$\frac{MS_A}{MS_{AB}}$
A:	$\sigma_A^2=0$	$\frac{MS_A}{MS_{B(A)}}$
	(assuming $I\sigma_B^2=\sigma_{AB}^2$)	

ANALYSIS OF DATA

In this section, the analysis of variance is applied to the data under two models: the crossed model and the nested model. Comparisons are made between the two model and a test is administered to determine the most appropriate model.

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[45] Henry Scheffé, The Analysis of Variance (New York: John Wiley and Sons, 1967), p.270.

[46] William H. Beyer, ed., Handbook of Tables for Probability and Statistics (Cleveland, Ohio: The Chemical Rubber Co., 1966), p.107.

Crossed Model

The technique of analysis of variance was applied to each of the indices of classroom climate mentioned in Chapter II, that is, (1) Teacher Talk Ratio (TTR); (2) Pupil Talk Ratio (PTR); (3) Content Cross Ratio (CCR); (4) Steady State Ratio (SSR); (5) Pupil Steady State Ratio (PSSR): (6) Indirect/Direct Ratio (IDR); (7) Pupil Initiation Ratio (PIR); (8) Revised Indirect/Direct Ratio (REVID); (9) Instantaneous Teacher Question Ratio (TQR89); (10) Instantaneous Teacher Response Ratio (TRR89); (11) Teacher Flexibility Ratio (TFR); and (12) Extended Indirect Influence Ratio (EIIR). These indices range from gross measures of student involvement in classroom interaction such as the Teacher Talk Ratio and Pupil Talk Ratio, to more refined measures such as the Extended Indirect Influence Ratio. Each index also attempts to look at a particular attribute of the classroom task structure which is important to the teaching-learning process. For example, the Instantaneous Teacher Response Ratio looks at the ability of the teacher to respond positively to student ideas, and integrate these ideas into class discussion. The Pupil Steady State Ratio is a measure of the amount of time pupils are given to answer questions or expand on their own ideas. In this sense, this study is of an exploratory nature, attempting to isolate the "degree," in some respect, that technology is able to affect classroom interaction. Table 3 displays the means and standard deviations for each of the twelve background variables.

Main Hypothesis

The following null hypothesis, then, was tested for

TABLE 3

MEANS AND STANDARD DEVIATIONS FOR ALL DEPENDENT VARIABLES

Variable	Mean	Standard Deviation
1. TTR	0.601	0.496
2. PTR	0.253	1.888
3. CCR	0.713	1.334
4. SSR	0.448	1.589
5. PSSR	0.225	0.811
6. IDR	0.254	1.017
7. PIR	0.011	0.002
8. REVID	0.741	0.013
9. TQR89	0.842	0.130
10. TRR89	0.244	0.117
11. TFR	0.014	0.154
12. EIIR	0.001	0.016

each index of classroom task structure:

> When the technology of the classroom organization is altered by introducing electronic computers and calculators into certain mathematics classes to be used by the teachers at their discretion, there will be no resulting change in the organizational task structure.

The critical F-value needed to test the hypothesis

$$H_A: \ \sigma_A^2 = 0$$

of no differences between treatments was $F_{1,12}(.05) = 4.75$. This critical F-value was exceeded by only the F-ratio for the Teacher Talk Ratio (see Table 4). The difference between treatments was in the direction of the control group, indicating that a significantly higher proportion of the classroom interaction in the control classes was devoted to teacher talk. On the average, the control classes spent 10.2 percent more of the total class time on teacher dominated behavior. This was 18.6 percent of the time that the experimental group spent on teacher dominated activities. Thus, the null hypothesis of no difference between treatments with respect to the Teacher Talk Ratio can be rejected at the .05 level of significance. The null hypothesis of no difference between treatments with respect to the other indices of classroom climate cannot be rejected (see Table 5).

Nested Model

The feasibility of pooling Teacher Pair and Interaction sums of squares into a single component called "Teacher" was examined. The pooling criterion used was:

$$\frac{MS_B}{MS_{AB}} < 2F_{12,12}(.50)$$

TABLE 4

ANALYSIS OF VARIANCE TABLE TEACHER TALK RATIO

Source	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio
Treatment	0.12172	1	0.12172	5.00136*
Teacher Pair	0.42958	12	0.03580	7.85134**
Interaction	0.29204	12	0.02434	5.33764**
Error	0.10487	23	0.00456	

*Denotes significance at the .05 level.
**Denotes significance at the .01 level.

TABLE 5

F-RATIOS FOR TESTING H_A: $\sigma_A^2=0$ WITH
1 AND 12 DEGREES OF FREEDOM
(CROSSED MODEL)

Background Variable	Mean Square Treatment	Mean Square Interaction	F-ratio MS_A/MS_{AB}
1. TTR	0.12172	0.02434	5.00136*
2. PTR	0.08582	0.01916	4.47863
3. CCR	0.09742	0.03106	3.13629
4. SSR	0.02790	0.02657	1.04996
5. PSSR	0.04907	0.03193	1.53657
6. IDR	0.00000	0.01120	0.00008
7. PIR	0.00037	0.00056	0.65256
8. REVID	0.01001	0.05074	0.19729
9. TQR89	0.00914	0.00682	0.54062
10. TRR89	0.00482	0.03313	0.14563
11. TFR	0.00001	0.00047	0.02700
12. EIIR	0.00001	0.00000	4.48170

*Indicates significance at the .05 level.

The critical F-value was 1.00, thus the critical ratio was 2.00. The data indicated that it was feasible to pool SS_A and SS_{AB} in all but three cases of the background variables. The results are summarized in Table 6. These results would indicate that the nested model is probably more appropriate for this research design than the crossed model. The nested model essentially assumes that teachers were not paired, that is, teachers are assumed to have been randomly chosen from the whole experimental or control group, and, are therefore said to be "nested within Treatment."

In summary, the data revealed that, with respect to the classroom task structure, the course effect was not as important as the teacher effect. For this reason, the nested model is taken as the most appropriate model of the research design.

Main Hypothesis

Once the nested model is taken as the most appropriate model for the experimental design, it is possible to test the hypothesis of no difference between treatments

$$H_A: \quad \sigma_A = 0$$

assuming $I\sigma_B^2 = \sigma_{AB}^2$, the condition for pooling. This was done for all background variables. The critical F-value was $F_{1,24}(.05) = 4.26$. This F-value was exceeded by only the F-ratio for the Pupil Talk Ratio (see Table 7). The difference favored the experimental group, that is, on the average, the classroom interaction for the experimental group tended towards a greater proportion of student talk than did the interaction of the control group. In fact, the exper-

TABLE 6

F-RATIOS FOR TESTING POOLING CRITERION†
WITH 12 AND 12 DEGREES OF FREEDOM

Background Variable	Mean Square Teacher Pair	Mean Square Interaction	Pooling Ratio MS_B/MS_{AB}
1. TTR	0.03580	0.02434	1.47083*
2. PTR	0.01970	0.01916	1.02818*
3. CCR	0.03764	0.03106	1.21185*
4. SSR	0.03106	0.02657	1.16899*
5. PSSR	0.05842	0.03193	1.82963*
6. IDR	0.02822	0.01120	2.51964
7. PIR	0.00036	0.00056	0.64286*
8. REVID	0.04574	0.05074	0.90146*
9. TQR89	0.04604	0.01690	2.72426
10. TRR89	0.02240	0.03313	0.67612*
11. TFR	0.00028	0.00047	0.59574*
12. EIIR	0.00001	0.00000	3.86712

†Criterion is to pool if and only if

$$\frac{MS_B}{MS_{AB}} < 2F_{12,12}(.50)=2(1.00)=2.00$$

*Indicates that SS_B and SS_{AB} may be pooled

imental classes spend 8.6 percent more of the total class time in pupil talk. This difference was 41 percent of the time that the average control group class spent on pupil dominated verbal behavior. Thus, the null hypothesis of no difference between treatments with respect to the

TABLE 7

ANALYSIS OF VARIANCE TABLE
PUPIL TALK RATIO

Source	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio
Treatment	0.08582	1	0.08582	4.41650*
Teacher (within Treatment)	0.46636	24	0.01943	6.20820*
Error	0.07197	23	0.00313	

*Denotes significance at the .05 level.

Pupil Talk Ratio can be rejected at the .05 level of significance. The null hypothesis of no difference between treatments with respect to the other indices of classroom task structure cannot be rejected under the nested model (see Table 8).

It is interesting to compare the F-ratios for testing H_A: $\sigma_A = 0$ under the crossed and nested model respectively. It can be shown that SS_B must be less than SS_{AB} in order for F_A^*, the ratio under the nested model, to be larger than F_A, the ratio under the crossed model. These ratios are compared in Table 9. Although most of the ratios did not differ significantly under either model, the Extended

TABLE 8

F-RATIOS FOR TESTING H_A: $\sigma_A^2=0$; Assuming $I\sigma_B^2=\sigma_{AB}^2$
WITH 1 AND 24 DEGREES OF FREEDOM
(NESTED MODEL)

Background Variable	Mean Square Treatment	Mean Square Teacher	F-ratio $MS_A/MS_{B(A)}$
1. TTR	0.12172	0.03007	4.04822
2. PTR	0.08582	0.01943	4.41650*
3. CCR	0.09742	0.03435	2.83596
4. SSR	0.02790	0.02881	0.96827
5. PSSR	0.04907	0.04518	1.08620
6. IDR	0.00000	0.01971	0.00004
7. PIR	0.00037	0.00046	0.80289
8. REVID	0.01001	0.04824	0.20749
9. TQR89	0.00914	0.03147	.29042
10. TRR89	0.00482	0.02777	0.17359
11. TFR	0.00001	0.00037	0.03355
12. EIIR	0.00001	0.00000	1.84142

*Denotes significance at the .05 level.

TABLE 9

F-RATIOS FOR TESTING H_A: $\sigma_A^2=0$ COMPARISON OF CROSSED MODEL WITH NESTED MODEL

Background Variable	Sum of Squares (Teacher Pair)	Sum of Squares (Interaction)	F-ratio† (MS_A/MS_{AB})	F*-ratio†† ($MS_A/MS_{B(A)}$)
1. TTR	0.42958	0.29204	5.00136*	4.04822
2. PTR	0.23642	0.22994	4.47863	4.41650*
3. CCR	0.45171	0.37273	3.13629	2.83596
4. SSR	0.37271	0.31883	1.04996	0.96827
5. PSSR	0.70101	0.38321	1.53657	1.08620
6. IDR	0.33861	0.13446	0.00008	0.00004
7. PIR	0.00430	0.00676	0.65256	0.80289
8. REVID	0.54891	0.60892	0.19729	0.20749
9. TQR89	0.55250	0.20283	0.54062	0.29042
10. TRR89	0.26880	0.39758	0.14563	0.17359
11. TFR	0.00337	0.00559	0.02700	0.03355
12. EIIR	0.00008	0.00002	4.48170	1.84142

*Denotes significance at the .05 level.
†Critical F-value: $F_{1,12}(.05) = 4.75$.
††Critical F-value: $F_{1,24}(.05) = 4.26$.

Indirect Influence Ratio (EIIR) made a radical change under the nested model. Of course, the Extended Indirect Influence Ratio failed to meet the pooling criterion in the first place. These results would indicate that the Extended Indirect Influence Ratio was highly course dependent. However, the Extended Indirect Influence Ratio was representative of another problem. Since this ratio is typically low due to the infrequency of responses falling into categories 1, 2, and 3, the time for which each teacher was observed was too short (total: forty minutes) to allow an accumulation of tallies in these categories. As a result, many cells contained very few or no tallies in these categories. Thus, the background variables that depended on certain rare classroom behaviors were based on fewer tallies than would be desirable. The Extended Indirect Influence Ratio was the most flagrant example of this phenomenon.

These results may not be startling to a researcher or practicing administrator aware of the enormous task implied by attempting to change human behavior, especially teacher behavior. Indeed, a major problem is that of encouraging teachers to utilize a new technology. A good parallel example is found in a study of Gross, Giacquinta, and Bernstein which also used systematic observation of teacher behavior.[47] The authors found that the reason a

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[47]Neal Gross, Joseph B. Giacquinta, and Marilyn Bernstein, An Attempt to Implement a Major Educational Innovation: A Sociological Inquiry (Cambridge, Mass.: Harvard University, Center for Research and Development on Educational Differences, 1968).

major organizational innovation was not properly implemented was due to two sources of difficulties: (1) the teachers' lack of clarity about the innovation, their lack of capabilities, and the lack of staff motivation; and (2) failure on the part of the administration to recognize that the teachers needed to be resocialized if they were to be able to conform to the new definition of their role and its failure to provide them with type of retraining they required, and the administration's failure to realize that instructional materials pertinent to the innovation did not exist at the time and that teachers had neither the skills nor the time required to develop them.[48] Thus, in this study, since the technology was given little administrative or consultative support, an unmeasured difference between treatments may well be due to improper implementation or the effect of semester credits in computer-related courses on the Steady State Ratio and the Indirect/Direct Ratio. In these cases the covariable accounted for nearly 50 percent of the teacher variability. Thus, removing the effect of the covariable "semester credits in computer-related courses," tended to reduce teacher variability on the measures of Steady State Ratio and Indirect/Direct Ratio.

Summary

There is some evidence that a technological change at the classroom level may cause a change in the organizational task structure. This evidence is not strong and

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[48] Ibid., pp. 184-187

tends to say that there may be less overall teacher-dominated verbal behavior in terms of Teacher Talk and more overall pupil-centered verbal behavior in terms of Pupil Talk. This evidence would give reserved support for the model ascribing to technology a major role in the organization; affecting the task structure of the organization. In light of the limited administrative and consultative support given to the implementation of this innovation it is quite conceivable that the technology itself had an unfreezing effect on the classroom teacher-pupil interaction. The evidence cited above gives some credence to the theory that technological change can cause such a disruption on the classroom structure. Any hope of more specific changes in classroom management other than the broad measures of Teacher Talk and Pupil Talk can be discarded without administrative and consultative support of the innovation.

Implications for Research and Practice

From the study implications for further research and for practice may be drawn.

Implications for Further Research

The results of this study suggested a possible relationship between technology and organizational task structure at the classroom level. If so, this would be consistent with the results of studies done in work organizations. Woodward,[49] for example, found that different

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[49] Joan Woodward, Industrial Organization: Behavior and Control (Oxford: Oxford University Press, 1970), 5-18.

technologies impose different constraints on individual members of organizations and on the choice of organizational structure. Woodward,[50] Blauner,[51] and Thompson[52] also found that higher production technology is associated with flexible and open organizations, and with autonomous ans satisfying work. This is supportive of the notion that emerged from the Tavistock Institute research, namely, that more sophisticated technology is a necessary condition in instituting autonomous group structures.[53] Thus, in this study, the introduction of computers to the classroom organization resulted in constraints on the students and teacher. The constraints were evidenced by less teacher talk and more pupil involvement in the class lesson. Futhermore, these results would support the notion of greater democratization and openness in the classroom. The support, however, is weak since other indices of autonomous student behavior were not significant.

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[50] Joan Woodward, Industrial Organization: Theory and Practice.

[51] Robert Blauner, Alienation and Freedom: The Factory Worker and His Industry (Chicago: The University of Chicago Press, 1964).

[52] James D. Thompson, Organizations in Action (New York: McGraw-Hill, 1967).

[53] E. L. Trist, G. W. Higgins, H. Murray, and A. P. Pollock, Organizational Choice (London: Tavistock Publications, 1963); also A. K. Rice, The Enterprise and Its Environment (London: Tavistock Publications, 1963), p. 293.

It is possible that the technology might have a more profound effect on the task structure of the classroom given a different setting. In particular, any further research in this area should attempt to insure a higher level of implementation of the technological innovation through administrative and consultative support, or at least assess the degree to which this implementation takes place. It seems plausible that maximum disruption can only occur through effective implementation of the innovation. A second suggestion for further research is to observe only classes studying identical subject matter, to the point of studying the same topical unit from identical textbooks. This would eliminate the problem of certain background variables being course dependent and also offer the advantage of terseness for the study. Finally, to overcome the problem of certain rare behaviors not being observed during the lesson, it is suggested that several visits be made to each classroom.

The results of this study offer implications for effecting planned organizational change in the classroom. In terms of social systems theory, technology, in the form of computers, created internal strain and imbalance among the classroom system subunits. This internal strain was the cause of the adaptation of teacher and pupils indirectly connected with the change point. That is, the dynamic created by introducing the computers was that of a force toward total systems restructuring to find a new equilibrium.

This is consistent with the research of Williams and Williams[54] who found that a catalyst-like expenditure on technological change created stresses which forced departments and units to compromise on objectives and abandon traditional routines and activities. Thus, the introduction of technology seems to provide a freedom to seek new ways of behaving. In particular, the teacher is given an excuse to break out of the traditional lecture mold and students are encouraged to have more input to the class lesson. This dynamic is called "unfreezing" and provides the basis for concluding that technological change would best precede social change in that it probably requires less time and elicits less resistance.[55] Thus, further change in the behavior of students and the teacher in the classroom organization would be facilitated by the disrupting effect of the computers. In particular, planned change in the form of teacher's classroom role from a dispenser of knowledge through group lectures, to a consultant through small group and individual contacts, might be assisted by the role of the computer as a catalyst, unfreezing the classroom structure. Further research needs to investigate the effectiveness of technology as a precursor and facilitator of

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[54] Lawrence K. Williams and C. Brian Williams, "The Impact of Numerically Controlled Equipment on Factory Organization."

[55] James C. Taylor, Technology and Planned Organizational Change (Ann Arbor, Michigan: Center for Research on Utilization of Scientific Knowledge, University of Michigan, 1971), pp. 18-19.

planned organizational change. It is especially important that more studies are done with the school organization. In this sense, additional research is also needed on the influence of different technologies than the computers used in this study.

Thus, the results of this study tend to give support to the task-technology-task structure model of Perrow and Woodward. Furthermore, these results seem to parallel those reported in studies on work organizations, even though the classroom organization resembled most of the work organizations only in its theoretical construct. Of particular interest is the utility of these results for supporting the notion of assigning a major role in planned organizational change to technology. The results would imply that there is at least some disruption in the organization caused by a change in technology. Additional studies might attempt to find the most fruitful ways to capitalize on this disruption in effecting permanent, planned organizational change in the school.

Implications for Practice

The implications from the results of this study to school administrators or change agents is twofold. First, if an administrator feels that on the basis of this research the task structure is affected by the technology, then the change in technology should be supported by appropriate administrative and consultative programs. This could be in the form of inservice to teachers, or released time, or additional pay to develop the skills and curricula required by the technology. Second, an administrator could well

decide on the basis of this research that the effect of a technological change on the classroom structure is minuscule. It may not be feasible to provide the extensive consultative support and inservice training necessary to change teacher behavior enough to ensure effective implementation. It is not even clear from this study that such support would prove fruitful. The most viable alternative might well be to employ teachers that already possess the sought after skills. For example, teachers that know how to program computers and who are experts at adapting the mathematics curriculum to gain maximum effectiveness from the technology. Similarly, the misuse and later abandonment of language laboratories may well have been prevented by hiring teachers knowledgeable in the effective use of the sophisticated technology posed by these laboratories rather than trying to retrain teachers used to conventional classrooms. This hiring procedure is now practiced by subject-matter departments in colleges and universities which hire faculty on the basis of "specialties" possessed by each faculty member. The union of all these areas of expertise results in a cohesive departmental structure. This procedure for seeking qualified faculty may well be viable for hiring secondary and elementary teachers.

In either case, the significant role of technology in the school organization cannot go unrecognized. The school administrator should consider the primacy of technology when determining a course of action that is to result in organizational change.